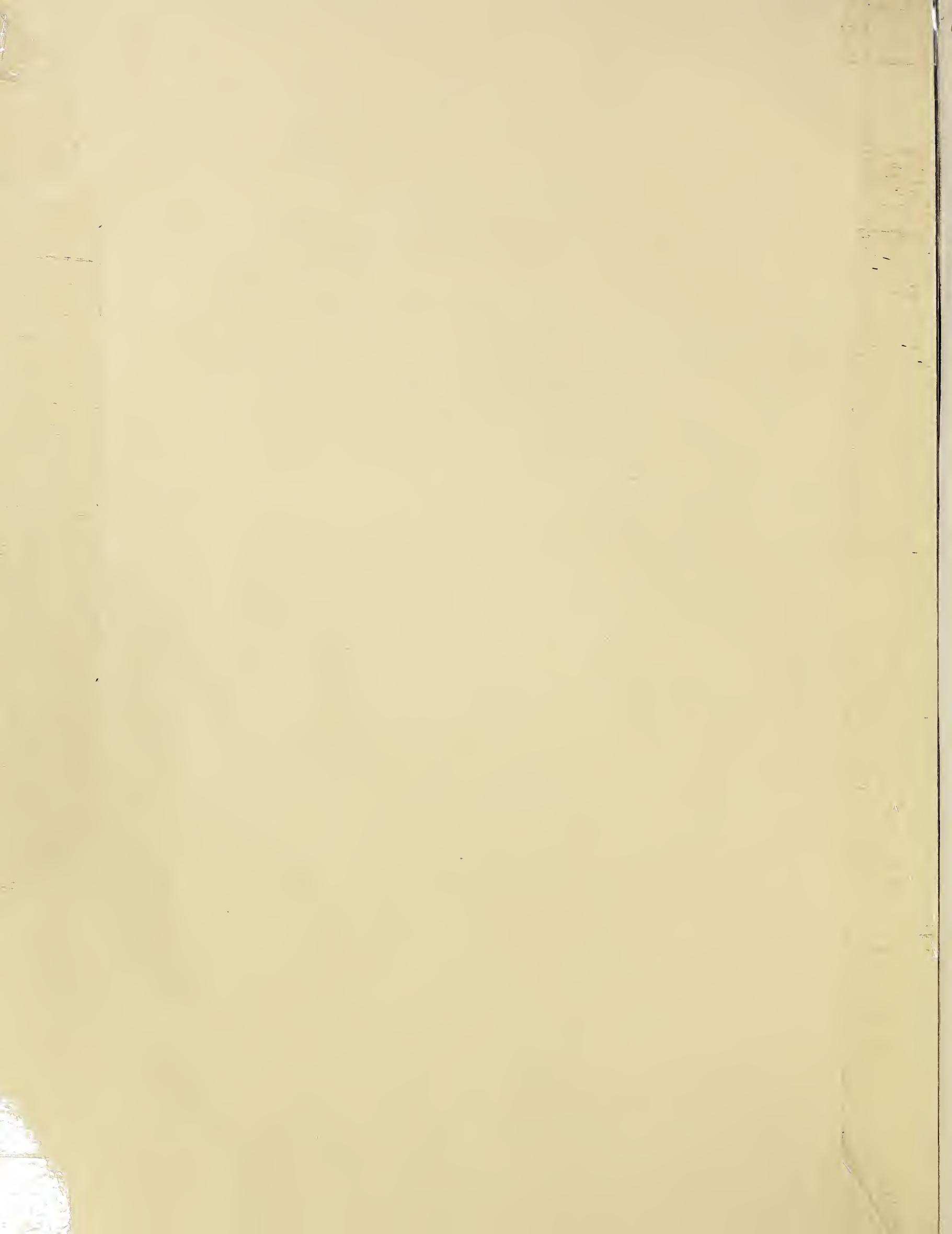


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THE EFFECTS OF SIMULATED SONIC BOOMS ON REPRODUCTION
AND SURVIVAL OF FARM-RAISED MILK

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U. S. DEPARTMENT OF AGRICULTURE
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U. S. DEPARTMENT OF AGRICULTURE/AGRICULTURAL RESEARCH SERVICE

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The U.S. Department of Agriculture was requested and funds were allocated by the U.S. Department of Defense's Air Force to study the effects of sonic boom on reproduction and behavior of farm-raised minks as part of the national sonic boom evaluation program. Subsequently, this program was transferred from the U.S. Air Force to the Federal Aviation Administration of the U.S. Department of Transportation.

The cooperation of the Harman Fur Farm (under contract) and the Neel Farm (by employment) of Christiansburg, Va., in furnishing the mink and assistance and the site for sonic boom tests, respectively, is gratefully acknowledged.

A complete measurement and simulation system provided by the NASA-Langley Research Center and the autopsies of the representative group of boomed mink kits conducted by the Veterinary Science Laboratory of Virginia Polytechnic Institute are also gratefully acknowledged.

The authors wish to acknowledge the contributions of Roy and Phillip Harman; Sally Neel; Raymond A. Shepanek, Deputy Chief of Sonic Boom Staff, FAA; and Col. John P. Taylor, USAF (retired), Executive Secretary, Committee on SST-Sonic Boom, National Academy of Sciences.

THE EFFECTS OF SIMULATED SONIC BOOMS ON REPRODUCTION AND
BEHAVIOR OF FARM-RAISED MINK

H. F. Travis, G. V. Richardson, J. R. Menear, and James Bond^{1/}

The U.S. Department of Agriculture was requested by the U.S. Department of Defense's Air Force to study the effects of sonic boom upon gestation, parturition, whelping, and early kit mortality of farm-raised mink as part of the national sonic boom evaluation program. Because mink are generally considered to be most sensitive to external stimuli during the reproductive period, booming during this period would be expected to give the most critical indications of possible harmful effects.

PROCEDURE

During spring of 1967, an experiment to determine the effects of simulated sonic booms on mink was carried out on two commercial mink farms in Virginia. The experiment was designed to determine the effects during the periods of gestation, parturition, and early lactation of random intermittent booming at pressure levels of 0.5 to 2.0 pounds per square foot overpressure.

Mink were housed on two commercial mink farms near Christiansburg, Va., where the ambient noise level was what would be expected in a quiet rural area. Mink were all from the Roy Harman Fur Farm (HFF) of Christiansburg and were representative animals from his pastel breeding herd. The feeding, handling, and care of the mink were all supervised by Phillip Harman, in order that management at the two sites would be as nearly identical as possible.

Three hundred pastel female mink were used. The females were bred between March 2 and 24 (before the test) according to Mr. Harman's routine breeding practices. Each group contained approximately one-half yearling (virgin) and one-half mink 2 years of age and older that had previous litters.

The first farm consisted of 180 individual pens (HFF), which housed control animals and were part of the regular mink farm (figs. 1, 2). The second farm, Neel Farm (NF), approximately 7 miles from the Harman Farm, was the site where the mink were boomed. These mink were housed in 120 individual pens in an open shed (NF) (figs. 3, 4, 5, 6).

The mink subjected to sonic booms were confined in individual cages along the east and west sides of the shed that had no walls or gable closure.

^{1/} Research Animal Husbandman, Animal Husbandry Research Division; Biometrician, Biometrical Service Staff; Agricultural Engineer, Agricultural Engineering Research Division; and Research Animal Husbandman, Animal Husbandry Research Division, Agricultural Research Service, USDA, Beltsville, Md., respectively.

Each cage was 3 feet long, 1.5 feet wide, and 1.6 feet high. Top and ends were of 1- by 1.5-inch wire mesh; the bottom was of 3/8-inch wire mesh; and the sides were of perforated steel sheet. A nest box of 1-inch thick board was attached to the inward end of the cage, and the cages were suspended on wires from the shed rafters.

An airplane moving at speeds greater than the speed of sound actually creates several shock waves. These waves may be produced by the nose, the cockpit canopy, the wings, the tail, and the engine air inlets. If one were standing close enough to the point of origin of the waves, a whole series of sonic booms could be heard. However, these waves tend to merge until, at the distance at which most observers hear them, there are only two waves--a nose wave and a tail wave. This sound wave is in three dimensions and is analogous to the bow wave coming off a boat in two dimensions. It moves along with the airplane just as the wave moves along with the boat. The bow wave reaches the ground first, creating a sudden but slight rise in atmospheric pressure--actually about one-thousandth of normal pressure of the atmosphere, which is 2,116 p.s.f. at sea level. The bow wave is followed almost immediately by the tail wave. These sudden shifts in pressure are called a sonic boom.

Usually an observer audibly discerns the shock wave created by a single aircraft as two separate pressure pulses, although the event is simply one of varying pressure. The first pulse is characterized by a sudden rise in pressure above the atmospheric level and the second pulse is characterized by a negative (with respect to the ambient atmospheric) pressure excursion ending with a rapid return to atmospheric pressure. Measurements of real sonic booms show that the pressure disturbances are sometimes more complex than a description of the event as a positive and negative pressure pulse. However, nearly all real sonic booms are, in a gross sense, typified by at least two pressure excursions both in the positive direction. The first is a rise above ambient pressure and the second is the return to ambient pressure from below. The effect of this form of pressure signature on the ear can be simulated by acoustic devices.

A simulated sonic boom for this experiment was generated by a unique device 2/ 3/ consisting of a large exponential horn, into which two charges of compressed gas were released sequentially by time-controlled rupture of two diaphragms. Output was controlled by pressure of the driving gas, nature of diaphragm material, and distance of subjects from the horn. These were adequate to establish an overpressure gradient between specified limits of 0.5 and 2.0 p.s.f. through the length of the mink shed.

2/ Ling-Temco-Vought, Inc., Instruction manual for sonic boom simulator (Unpublished.) LTV Research Center, Western Division, Anaheim, Calif. February 27, 1967.

3/ NASA-LTV Sonic boom simulator. (Unpublished.) NASA-Langley Research Center, Hampton, Va. March 13, 1967.



Figure 1.--Overall view, Harman Fur Farm



Figure 2. Detail of pens and nest boxes. Harman Fur Farm.



Figure 3.--Simulated sonic boom device with mink shed in background.

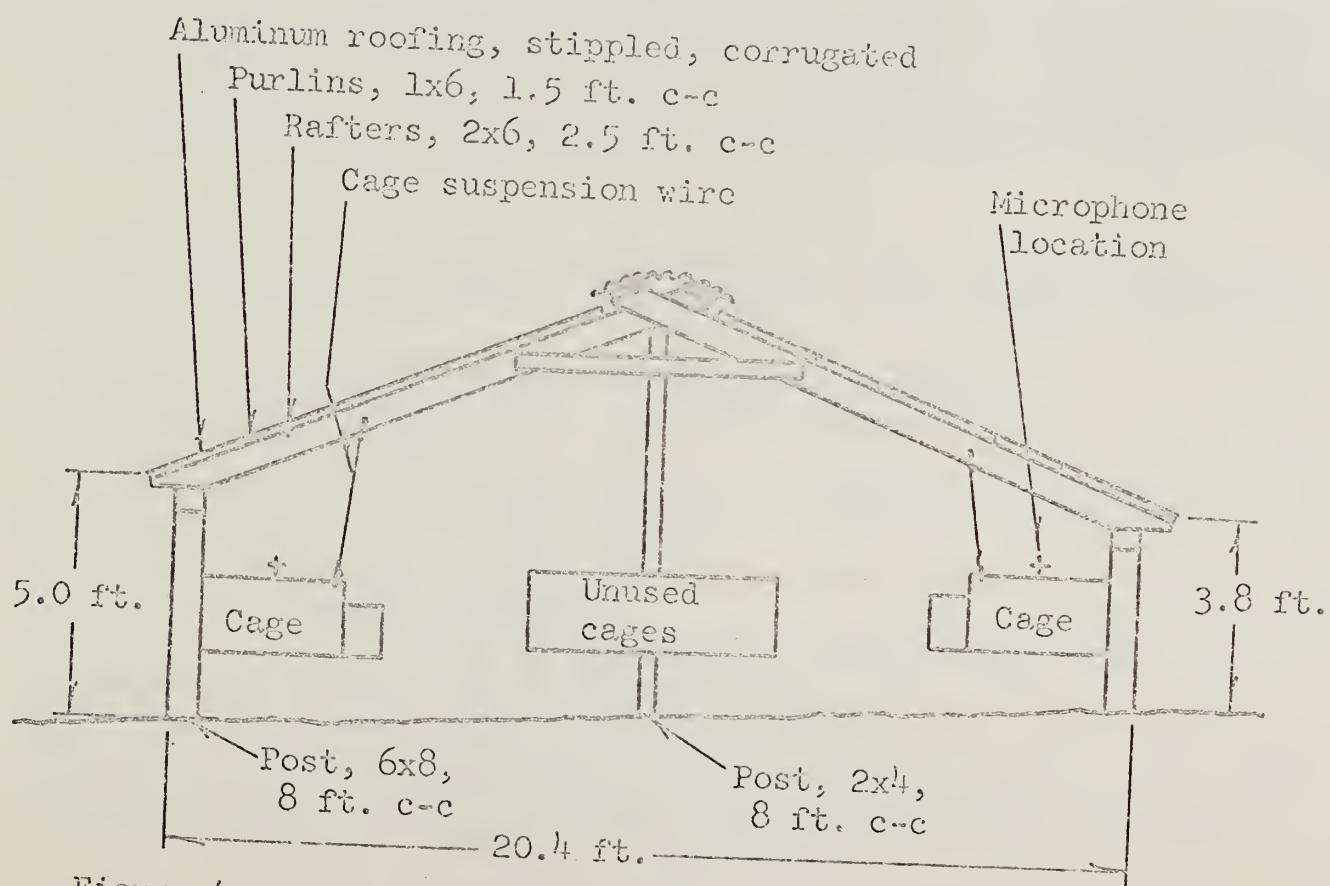


Figure 4.--Cross section of shed for simulated boom exposure.

The recorded wave shape of the simulated boom is shown in figure 7. It resembles that of a typical real boom only in the essential features--two rapid positive pressure excursions starting pulses timed 150 msec. apart. Each pulse included a full alternation cycle within about 8 msec., the negative peak of which departed from ambient pressure by about 1.15 times the peak positive value. The simulated boom pulse thus included three main pressure excursions rather than the single excursion of the typical real boom pulse, although the second and third excursions were of lesser rise rate. After one and one-half more cycles of small amplitude and lengthening period, each pulse was essentially complete in a total time of 33 msec. The second pulse of each boom was slightly reduced in both peak pressure and rise rate, compared to the first. The pulses contained considerable noise; a frequency of about 485 hertz was prominent but transient, as was a mixture of higher frequencies. The simulated boom traversed the mink shed at sonic speed and decayed in form, as well as peak pressure. At the front of the shed, pressure-rise rate of the first excursion was recorded as about 12 p.s.f. per msec.; at the rear it was only 0.25 p.s.f. per msec.

Peak overpressure through the shed (fig. 8) ranged between 0.5 and 2.0 p.s.f. in a smooth gradient. Continuous pure tones having these pressure amplitudes would be of intensities 130.6 and 118.6 decibels, respectively, referred to 0.2 nanobar. However, the peak pressure in the boom is instantaneous. Both the rise in overpressure and its decay are very rapid and can be measured in hundredths of a second. The shed length was divided into thirds to give three subranges of overpressure for the experimental design. The means of these were 1.56, 0.91, and 0.60 p.s.f. Intensity of the simulated boom was monitored by a system of instruments previously developed for sonic boom field measurement^{4/}, consisting of specially modified capacitor microphones, with associated units for tuning, amplifying, and recording. A complete measurement and simulator system was provided by the NASA-Langley Research Center. Operation, however, was entirely by USDA personnel.

The experimental design was as follows: Mink were randomly divided into seven groups according to age and subjected to the following treatments:

- (1) 60 females, maintained at HFF; not boomed or moved.
- (2) 20 females, maintained at HFF; moved and returned to new pens at start of test (April 8). Not boomed.
- (3) 20 females, maintained at HFF; moved and returned to new pens just before whelping period (April 18). Not boomed.
- (4) 20 females, maintained at HFF; moved and returned to new pens at start of test and again just before whelping.
- (5) 60 females, moved from HFF to NF April 8; boomed eight times per day during pregnancy; and returned to HFF April 18.
- (6) 60 females, moved from HFF to NF on April 18 and boomed eight times per day during the late gestation and whelping period.
- (7) 60 females, moved from HFF to NF at start of tests and subjected to eight booms per day throughout pregnancy and whelping.

^{4/} Hilton, D. A., and Newman, Jr., J. W. Instrumentation techniques for measurement of sonic-boom signatures. Jour. Acoustical Soc. Amer. 39(5): 531. 1966.

ARS 44-200

June 1968

THE EFFECTS OF SIMULATED SONIC BOOMS ON REPRODUCTION
AND BEHAVIOR OF FARM-RAISED MINK

Errata Sheet for Page 9

The statistical model as given on Page 9 is misprinted and should read as follows:

$$Y_{ijklmnpq} = \mu + A_1 + B_{1j} + C_{1jk} + D_{ijkl} + E_{im} + F_{im} + \text{Days}_p + \text{all two-way interactions of Days}_p \text{ with } A_1 \text{ through } F_{im} + \epsilon_{ijklmnpq}$$

A_1 = control females not subject to booms vs. boomed females that were subject to booms.

B_{1j} = control females that were moved vs. control females that were not moved.

C_{1jk} = control females that were moved once vs. control females that were moved twice.

D_{ijkl} = control females moved only on the first move vs. control females moved only on the second move.

E_{im} = boomed females that were boomed only one-half of the time vs. boomed females that were boomed the entire time.

F_{im} = boomed females boomed during the first one-half time vs. boomed females during the latter one-half time.

DAYS_p = effect of days 1, 5 and 19.

Starting April 25, all females were observed to determine whether or not they had whelped. Each female was also observed the day after birth of the kits and at 5 and 10 days after whelping to determine the number of kits born alive and dead, and mortality after whelping. Observations were discontinued 11 days following the whelping of each litter. Representative kits that died from the boomed mink groups were autopsied to determine the cause of death.

The daily boozing of the mink was initiated on April 8, when the first mink were taken to the Neel Farm, and was discontinued June 1. Mink were boozed four times between 0930 and 1130 and four times between 1300 and 1530. The times were picked at random with no less than 10 minutes between booms.

The statistical procedures were as follows: The data collected on the number of live kits at 1, 5, and 10 days post whelping were subjected to analyses of variance using unequal subclass number techniques as described by Harvey ^{5/}. Three separate analyses were used and will be referred to hereafter as analysis I, analysis II, and analysis III.

Analysis I included all females on the experiment whether they whelped or not. The least squares model was as follows:

$$Y_{ijklmnpq} = \mu + A_i + B_{ij} + C_{ijk} + D_{ijkl} + E_{im} + F_{imn} + \text{Days}_p + \text{Litter size of an individual female} + \text{all two-way interactions of days}_p \text{ with } A_i \text{ through } F_{imn} + e_{ijklmnpq}$$

μ - litter size of an individual female.

A_i - control females not subject to booms (A1) vs. boomed females that were subject to booms (A2).

B_{ij} - control females that were moved vs. control females that were not moved.

C_{ijk} - control females that were moved once vs. control females that were moved twice.

D_{ijkl} - control females moved only once on the first move vs. control females moved only once on the second move.

E_{im} - boomed females that were boomed only one-half of the time vs. boomed females that were boomed the entire time.

F_{imn} - boomed females boomed during the first one-half time vs. boomed females during the latter one-half time.

Days_p - effect of days 1, 5, and 10.

Each female was observed on days, 1, 5, and 10. Therefore, to measure the effects of days and all interactions involving days, the individual animal effects should be removed. All other effects are measured from different females and cannot be adjusted for animal differences. Thus, there are two error terms, the among animal variation and the within-animal variation. The effects of A_i through F_{imn} were adjusted for all effects in the model and the

^{5/} Harvey, W. R. Least squares analysis of data with unequal subclass numbers. U.S. Dept. Agr., Agr. Res. Serv., ARS 20-8, 157 pp 1960.

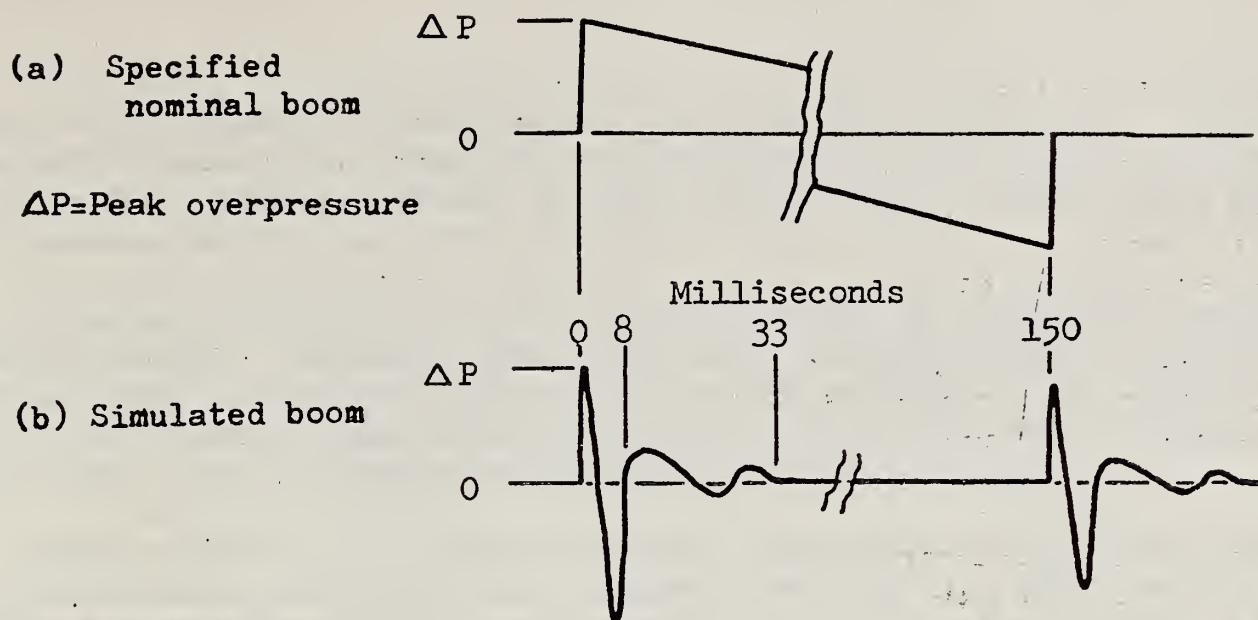


Figure 7.--Pressure-time plot of simulated boom.

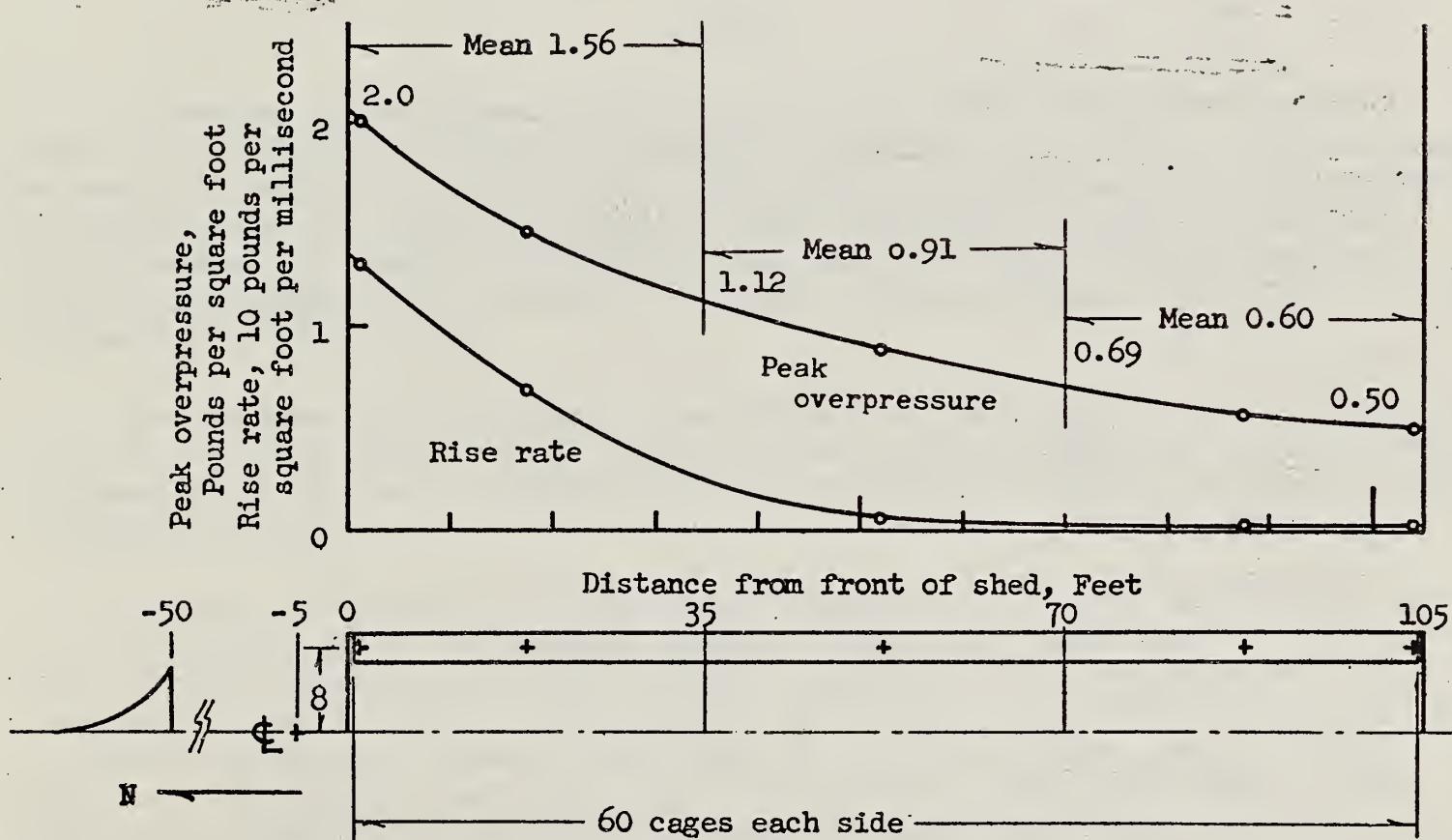
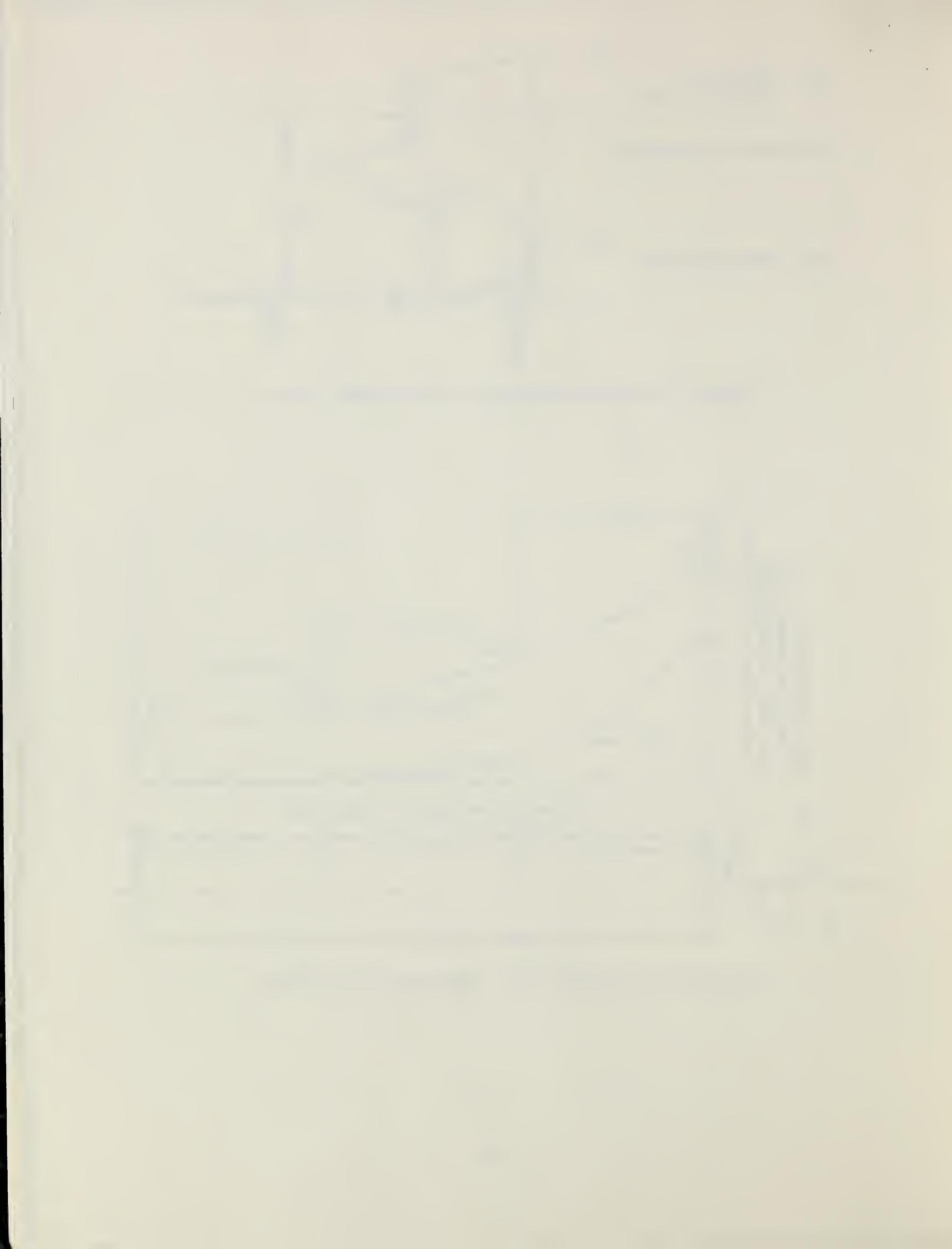


Figure 8.--Arrangement for simulated boom exposure.



F-ratio test included the among animal error as the denominator. The day effects and interactions with days were adjusted for all effects in the model, as well as the individual animal effects and the within animal error was used as the denominator in the F-ratio tests.

The model in analysis II was exactly the same as analysis I and the same discussion applies. Different data were used in that analysis II included only those females that had whelped. Since the proportions of females that did not whelp were not abnormally high, it was felt that this analysis was necessary for a more complete evaluation of the litter sizes.

Analysis III was utilized to determine the effect of adjusting the 5- and 10-day litter sizes for the initial litter size (day 1). This was accomplished by adding a covariate ($b(X-\bar{X})$) the regression of litter size (5 and 10 days) on initial size (day 1) to the analysis I model. The use of this analysis was to take into account the natural occurrence of larger probabilities of losses in the larger litters. Data subjected to this analysis were those for the females that had whelped.

RESULTS

A summary of reproduction data is shown in table 1 and results of pertinent statistical analyses are shown in tables 2, 3, and 4. The difference between the analysis of productivity per female on experiment and the analysis of productivity per female whelping is that the first analysis takes into consideration the females that did not produce, and thus is an evaluation of overall production. The analysis of productivity per female whelping is an evaluation of litter size.

The average production per female kept for pastel mink on the Harman Farm was 3.92 in 1962, 4.04 in 1963, 4.02 in 1964, 3.32 in 1965, and 3.85 in 1966. Production was lowered in 1965 because of inadvertent feeding of spoiled feed at whelping time.

Average production of 2,276 pastel females on 11 farms in Manitoba was recorded by Kirk 6/. The average number of kits per female kept on the different farms varied from 2.4 to 5.2 with a mean of 4.0. The average litter size varied from 3.7 to 5.7 with a mean of 5.0 kits per litter. The percentage of females producing litters varied from 75.0 to 93.7 with a mean of 80.8. Thus, it would appear that the overall production of the mink used in this study was comparable to the normal production reported by Kirk (3.8 kits per female kept, average litter size 4.5, and 85.7 percent whelping). Since all groups of mink were bred in a similar manner before the moving or booming was initiated, the production of kits per female whelping is considered to be a

6/ Kirk, R. J. Manitoba Mink Production. American Fur Breeder 38(7): 11. 1965.

more valid criterion of reproductive performance in this experiment. The regression analyses of the litter size of 5 and 10 days on the litter size at 1 day were conducted because of the higher mortality normally expected to be associated with litters that were initially larger.

When the productivity of all the boomed mink were compared against that of the unboomed mink (table 1, groups 1, 2, 3, 4 against 5, 6, 7) production was significantly greater (table 2) in the groups that received the sonic boom when calculated on the basis of kits per female on experiment, but not on the basis of kits per female whelping. The litter sizes were not statistically different. However, 94 out of 120 control females whelped 78 percent; whereas 163 out of 180 boomed mink whelped 91 percent. This is the reason for the statistically significant difference in productivity when measured on the basis of females on experiment.

As would be expected there was a significant difference between days on all analyses. This was because there were fewer kits at 10 days than at 1 day.

There was no statistically significant difference between the groups that received different intensities of the sonic boom (table 1).

In the analysis of variance of production per female on experiment and the analysis of production per female whelped, interactions of the control vs. boomed by days and boomed one-half vs. boomed all by days were significant (table 2). These interactions indicated that the boomed mink (table 1, group 5, 6, 7) had a greater mortality between birth and 10 days than the mink in the control group 1, 2, 3, 4. They also indicate that mothers boomed during the entire period (table 1, group 7) had a slightly greater kit mortality than the mothers boomed during only one-half of the period, (group 5, 6).

It has been demonstrated ^{7/} that larger litters tend to decrease more as time passes. The litter average at day one for these groups was as follows: Boomed 4.8, not boomed 4.6, boomed entire period 4.9 and boomed half-time 4.6. In order to compensate for the differences in initial litter size, a covariance analysis was conducted. This too indicated (tables 1 and 4) that the mortality in the mink boomed during the whole booming period was significantly greater than those boomed only one-half of the time.

These results raised the question whether or not there might be a location effect (general environment on the Harman vs. Neel farms) aside from the effect of the sonic boom itself. It was impossible to make a comparison because it is impossible to have boomed and control animals at the same location. The kit mortality on the Neel Farm was higher than that of the Harman Farm (table 1 groups 6, 7 vs. groups 1, 2, 3, 4, 5). However, we are again faced with the problem that this was primarily caused by losses in group 7 (boomed all the time at the Neel Farm). The kit mortality in group 7 was 15.5 percent. Losses in group 6, which also whelped at the Neel Farm were 6.5 percent,

^{7/} Johansson, I. Minkens Fort Planting. Vara Palsdjur 11: 73-77. 1940.



TABLE 1.—Summary of reproduction data of boomed and unboomed mink
Aceman and Neel Farms, Christiansburg, Va., 1967

Treatment	Exptl. Group	Number of females on experiment	Number of females whelped	Percent mortality of kits born to 10 days	Number of kits alive		Percent mortality of kits born to 10 days	Live kits per female		LSM ^{1/}	LSM ^{2/}	LSM ^{3/}	LSM ^{4/}	LSM ^{5/}
					1 day	10 days		On experiment average 1, 5, 10, 15, 20 days	That whelped average 1, 5, 10, 15, 20 days					
Not boomed	1, 2, 3, 4	120	94	4.50	44.1	427	7.2	3.6	4.5	4.6	4.5	4.5	4.5	4.5
Not moved	1	60	52	6.6	252	247	7.1	4.2	4.8	4.3	4.8	4.3	4.3	4.3
Moved	2, 3, 4	60	42	16.4	189	180	7.2	3.0	4.3	4.4	4.2	4.2	4.2	4.2
Moved early (April 8)	2	20	15	7.5	72	70	2.9	3.5	4.4	4.5	4.4	4.4	4.4	4.4
Moved late (April 18)	3	20	12	6.0	59	51	13.6	2.6	4.1	4.3	3.9	3.9	4.0	4.0
Moved early + late	4	20	15	7.5	63	59	6.3	3.0	4.0	4.1	3.9	3.9	3.9	3.9
Boomed ^{2/}	5, 6, 7	180	163	9.1	792	774	7.24	8.6	4.1	4.6	4.8	4.5	4.4	4.4
Boomed early	5	60	55	92	254	252	246	3.1	4.1	4.5	4.6	4.5	4.5	4.5
Boomed late	6	60	53	88	260	254	243	6.5	4.0	4.6	4.7	4.6	4.5	4.5
Boomed half time (early or late)	5, 6	120	108	90	514	506	489	4.9	4.1	4.6	4.6	4.5	4.5	4.5
Boomed all time (early or late)	7	60	55	92	273	268	235	15.5	4.2	4.6	4.9	4.5	4.3	4.3
Intensity of boom:														
Low (0.5-0.69 (2/)		53	45	85	215	210	194	9.8	3.8	4.4	4.7	4.3	4.3	4.3
Medium (0.69-1.12 (2/)		54	51	96	246	242	222	9.8	4.4	4.6	4.8	4.5	4.4	4.4
High (1.12-2.0 (3/)		54	49	91	243	236	229	5.8	4.3	4.7	4.8	4.7	4.6	4.6
Location of whelping ^{4/}														
On Harman farm	1, 2, 3, 4, 5	130	149	83	714	693	673	5.7	--	4.7	--	4.5	--	4.4
On Neel farm	6, 7	120	108	90	538	522	478	11.2	--	4.8	--	4.8	--	4.4
1/ Least Square Means (LSM)														
2/ All boomed mink were also moved. Mink that were boomed early and late were moved early (April 8), mink that were boomed late were moved late (April 18), and mink boomed early were moved early and late.														
3/ One third of each of groups five, six, and seven received booms at each level of intensity.														
4/ Not subjected to statistical analysis.														
5/ Ray Means (RM).														



TABLE 2.--Least squares analysis of variance of production of live kits
PER FEMALE ON EXPERIMENT

Item	Degree of freedom	Mean Squares	F	Sig. 1/
A, Control vs. boomed -----	1		3.620	0.06
B, Moved vs. not moved ----- (within control)	1		6.594	.02
C, One move vs. two moves ----- (within control)	1		.021	N.S.
D, First move vs. second move ----- (within control)	1		1.562	N.S.
E, Boomed one-half vs. boomed all --- (within boomed)	1		.048	N.S.
F, boomed early vs. boomed late ----- (within boomed)	1		.050	N.S.
Animal error -----	239	16.1384		
Days -----				
A X days -----	2		14.269	<0.005
B X days -----	2		4.070	.02
C X days -----	2		.389	N.S.
D X days -----	2		.144	N.S.
E X days -----	2		.432	N.S.
F X days -----	2		6.379	<0.005
Within animal error -----	586	0.2510	.144	N.S.

PER FEMALES THAT WHELP

A, Control vs. boomed -----	1	0.011	N.S.
B, Moved vs. not moved ----- (within control)	1	1.803	N.S.
C, One move vs. two moves ----- (within control)	1	.865	N.S.
D, First move vs. second move ----- (within control)	1	.240	N.S.
E, Boomed one-half vs. boomed all --- (within boomed)	1	.000	N.S.
F, Boomed early vs. boomed late ----- (within boomed)	1	.031	N.S.
Animal error -----	250	10.3841	
Days -----			
A X days -----	2	13.935	<0.005
B X days -----	2	2.799	.06
C X days -----	2	.691	N.S.
D X days -----	2	.305	N.S.
E X days -----	2	.848	N.S.
F X days -----	2	5.871	<0.005
Within animal error -----	5.00	0.2905	.158

1/ N.S. indicates no significant differences at probability levels <0.10.



TABLE 3.--Least squares analysis of variance of effect of intensity of boom on live kits per female that whelp

Item	Degree of freedom	Mean Squares	F	Sig. ^{1/}
A, Boomed one-half vs. boomed entire	1		0.035	N.S.
E, Boomed second half vs. first half	1		.668	N.S.
I, Intensity	2		.235	N.S.
A X I	2		.282	N.S.
B X I	2		.968	N.S.
Animal error	136	10.59790		
Days	2		11.385	<0.005
A X days	2		5.409	.005
B X days	2		.251	N.S.
I X days	4		.430	N.S.
A X I X days	4		.393	N.S.
B X I X days	4		.821	N.S.
Within animal error	272	0.3818		

^{1/} N.S. indicates no significant differences at probability levels <0.10.



TABLE 4.--Covariate analysis with regression of number of kits at 1 day on the number of kits at 5 and 10 days

Item	Degree of freedom	Mean Squares	F	Sig. 1/
A, Control vs. boomed -----	1		2.278	N.S.
B, Moved vs. not moved ----- (within control)	1		1.284	N.S.
C, One move vs. two moves ----- (within control)	1		0.136<	N.S.
D, First move vs. second move ---- (within control)	1		1.130	N.S.
E, Boomed one-half vs. boomed all- (within control)	1		5.086	0.025
F, Boomed early vs. boomed late -- (within control)	1		0.072	N.S.
G, Regression on the no. of ----- live kits at day 1	1		1094.680	<0.005
Animal error -----	249	1.3467		
Day 5 vs. day 10 (days) -----	--		4.923	0.03
A X days -----	--		3.774	0.05
B X days -----	--		0.349	N.S.
C X days -----	--		0.075	N.S.
D X days -----	--		0.208	N.S.
E X days -----	--		7.093	0.01
F X days -----	--		0.389	N.S.
Within animal error -----	250	0.1112		

1/ N.S. indicates no significant differences at probability levels <0.10.



compared to a range of from 2.9 to 13.6 percent losses of mink whelping on the Harman Farm. However, overall production at 10 days (kits per female on experiment) in group 7 was 3.9. By this method of evaluation the production was higher on the Neel Farm (4.4) than on the Harman Farm (3.7) and higher for the boomed mink (4.0) than for the mink not boomed (3.6). Mink boomed during one-half of the period had an overall production of 4.1, compared to 3.9 for those boomed early and late.

There did not appear to be any noticeable changes in behavior of the mink in response to the booms. When mink were boomed for the first time, a few of them responded by coming out of their nest boxes or moving around in the pen in a manner to convey interest in what caused the noise. There was no response at all in the majority of the animals. There was no racing up and down the pen or squealing that is usually indicative of a high state of agitation in mink. No abnormal behavior was observed throughout the experiment.

Autopsies on the representative group of boomed mink kits found dead (42 of 60) were conducted by the Veterinary Science Laboratory of Virginia Polytechnic Institute. Nothing was observed that could be attributed to the effects of the sonic boom.

CONCLUSIONS AND SUMMARY

During spring of 1967, a study was conducted by the Agricultural Research Service, U.S. Department of Agriculture, in cooperation with the U.S. Department of Defense's Air Force (later transferred to Federal Aviation Administration of the U.S. Department of Transportation) on two commercial mink farms in Virginia to determine the effects of sonic booms by simulation upon pregnancy, parturition and early kit mortality of farm-raised mink. The sonic booms were simulated by a compressed air-booming device, which produced overpressures in the general range of magnitude of 0.5 to 2.0 p.s.f. The simulated booms were initiated on April 8 (after breeding) and terminated June 1 (after youngest kit was 11 days old).—Three hundred breeding pastel females and over 1,250 kits were used. The results were as follows:

(1) Kit production per female on experiment for the mink receiving the sonic boom treatment was statistically higher than that of the control (724 live kits at 10 days from 180 females for an average per female kept of 4, compared to 427 live kits from 120 females for an average of 3.6). This was primarily because of higher percentage of females whelping.

(2) The percentage of females whelping was 91 percent for the boomed mink compared to 78 percent for mink that did not receive the boom.

(3) On a basis of kits per female whelping, the mink receiving the sonic boom treatment had slightly smaller litters (not statistically significant) at 10 days (4.4 kits per female whelping compared to 4.5 kits per female whelping in the groups not boomed).

